LOCKHEED MARTIN

ADST-II-CDRL-VTI-9800081
April 15, 1998

ADVANCED DISTRIBUTED SIMULATION TECHNOLOGY II (ADST II) VIRTUAL TERRAIN IMAGERY (VTI) EXPERIMENT (DO #0059) CDRL AB02

FINAL REPORT

FOR: NAWCTSD/STRICOM
12350 Research Parkway
Orlando, FL 32826-3224
N61339-96-D-0002
DI-MISC-80711

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Approved for public release; distribution unlimited.

UNCLASSIFIED

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	15 Apr 1998	Final Report

4. TITLE AND SUBTITLE
Advanced Distributed Simulation Technology II (ADST II) Virtual Terrain Imagery (VTI) Experiment CDRL AB02 Final Report

5. FUNDING NUMBERS
N61339-96-D-0002

6. AUTHOR(S)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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8. PERFORMING ORGANIZATION REPORT NUMBER
ADST-II-CDRL-VTI-9800081

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

NAWCTSD/STRICOM
12350 Research Parkway
Orlando, FL 32826-3324

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
A - Approved for public release; Distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 Words)***
The Virtual Terrain Imagery (VTI) was an experimental exercise conducted at the Mounted Warfare Test Bed (MWTB) at Fort Knox, KY from February 23 to April 3, 1998. The experiment was performed as Deliver Order (DO) #0059 under the Lockheed Martin Advanced Distributed Simulation Technology II (ADST II) Contract administered by the U.S. Army Simulation, Training, and Instrumentation Command (STRICOM). The Mounted Maneuver Battle Lab (MMBL), Fort Knox, KY sponsored the experiment. The experiment utilizes linked constructive and virtual simulation systems portraying an Indirect-Fire-supported Armor Company-Team advancing in Meeting Engagement scenarios with multiple maneuver options. Scenarios were developed to run on the Grafenfels terrain database.

14. SUBJECT TERMS
ADST-II, STRICOM, Simulation, VTI

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

Document Control Information

Revision	Revision History	Date
	Initial Release	04/15/98

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Executive Summary

The Virtual Terrain Imagery (VTI) was an experimental exercise conducted at the Mounted Warfare Test Bed (MWTB) at Fort Knox, KY from February 23 to April 3, 1998. The experiment was performed as Delivery Order (DO) #0059 under the Lockheed Martin Advanced Distributed Simulation Technology II (ADST II) Contract administered by the U.S. Army Simulation, Training, and Instrumentation Command (STRICOM). The Mounted Maneuver Battle Lab (MMBL), Fort Knox, KY sponsored the experiment. The experiment utilizes linked constructive and virtual simulation systems portraying an Indirect-Fire-supported Armor Company-Team advancing in Meeting Engagement scenarios with multiple maneuver options. Scenarios were developed to run on the Grafenfels terrain database. The objectives of the effort were:

a) To evaluate the effectiveness of virtual terrain imagery on combat decision making by staff officers using constructive simulation in Maneuver and Engagement exercises.

b) To assess the effectiveness of constructive simulation updates on tank commander performance in simulation exercises.

c) To establish procedures for using linked constructive and virtual simulation displays during selected mission and tactical situations.

d) To identify display characteristics that most effectively impact performance and training of staff officers and vehicle commanders during simulation exercises.

Development of the software modifications to Modular Semi-Automated Forces (ModSAF) and the initial integration of software models were conducted at the MWTB in Ft. Knox, KY from December 6, 1997 to January 23, 1998. The final integration phase was completed at the MWTB from February 17 to 20, 1998.

The original Government Statement of Work (SOW) called for a test trial window of six (6) weeks. This six-week period included a week of training/pilot testing and two weeks to execute the trial run matrix for each of two teams. Scheduling conflicts for the use of the M1A2 simulators reduced the availability to four weeks. Experienced Research Assistants (RA) were used to staff the experiment allowing the training/pilot-testing period to be compressed to one day per team. The RA were able to meet or exceed the goal of 10 trial runs per day.

In accordance with the Government SOW, this Final Report includes a description of the experiment, its conditions and conduct, and lessons learned. This report addresses the interconnectivity of simulation systems, and modifications to both ModSAF and the manned simulators. This report does not include discussion of data analysis nor conclusions as to whether the customer(s) achieved their objectives from the experiment.

1. Introduction

1.1 Purpose

The purpose of this final report is to document the ADST II effort to support the VTI experiment. The final report includes a full description of the experiment, its conditions, and lessons learned. It describes the VTI architectural design (i.e., diagrams and listings of network, simulator, and connections down to the cable level). This includes a detailed description of the subcomponents of the overall system and their interoperation. This document should be consulted to recreate the connectivity and functionality of the equipment should the equipment be reused in a future experiment.

1.2 Contract Overview

VTI was performed as DO #0059 under the Lockheed Martin Corporation (LMC) ADST II contract with STRICOM.

1.3 Experiment Overview.

The purpose of VTI was to evaluate the impact of providing virtual-simulation terrain detail to tactical commanders and staff during Janus constructive-simulation training exercises, while probing details of the decision logic applied for terrain situational assessment during those exercises. Data was collected to capture the command and battle staff and tank commander's use of combined imagery of a direct view of the battlefield and schematic displays on micro-maneuver decisions. The experiment was designed to provide the Government with the opportunity to perform detailed analysis and training of user situational assessment skills. It was also designed to assess the tactical value of combined battlefield representations (virtual and schematic) to capture global terrain characteristics for weapon system emplacement and maneuver advantage. The actual experiment employed one manned M1A2 simulator, one Blue ModSAF M1A2 wingman, a battery of Blue ModSAF M109s and a Company Commander and Fire Support Officer role-playing from ModSAF workstations. The Blue Force (BLUEFOR) conducted stealthy maneuver operations against sequentially exposed Opposing Force (OPFOR) ModSAF target BMP2s. The World Modeler and Janus were not used in the experiment because they could not provide the necessary realism required of manned simulators.

1.4 Technical Overview

The technical approach to the Virtual Terrain Imagery Experiment involved integrating the manned M1A2 simulator and ModSAF, making modifications to ModSAF version 3.0, and correlating the terrain used by the manned M1A2 simulator and ModSAF. Details on the modifications to ModSAF are documented in the Version Description Documents (VDD), (CDRL A00C). The following is a short synopsis of the technical integration effort for the experiment.

ModSAF development was conducted at the MWTB during the test and development portion of integration. An informal Test Readiness Review (TRR) was held on February 19, 1998 to freeze the experiment configuration and receive approval to start the experiment, which began on February 24, 1998. Once the synthetic environment functional tests were completed, Fort Knox conducted troop training and a Pilot Test. The actual experiment period lasted four weeks. A minimum of 85 trial runs per team was set as a goal prior to the start of the experiment. The first team ran 99 trials and the second team ran 140 trials. Four basic scenarios were used. Approximately half of the trial runs were augmented runs. An augmented run had the company commander's ModSAF view displayed in the M1A2 simulator and the M1A2 copula center view displayed at the company commander's workstation.

2. Applicable Documents

2.1 Government

ADST II Delivery Order Statement of Work for Virtual Terrain Imagery (VTI), August 28, 1997, AMSTI-97-WO71, Version 1.0

ADST II Delivery Order Statement of Work for Virtual Terrain Imagery (VTI), February 9, 1998, AMSTI-97-WO71, Version 2.0

2.2 Non-Government

ADST II, Virtual Terrain Imagery (VTI) Experiment ModSAF Version Description Document, April 15, 1998, ADST-II-MISC-VTI-9800088

3. System Description

3.1 System Configuration and Layout

The Mounted Warfare Test Bed at Fort Knox, KY, contains a variety of vehicle simulators, networks, Semi-Automated Forces (SAF) capabilities, displays for monitoring the battlefield, utilities to facilitate exercises, automated data collection capabilities, and data reduction and analysis subsystems. The MWTB provided all equipment used for the VTI experiment. The MWTB simulation and support platforms used for VTI are depicted in Figure 1.

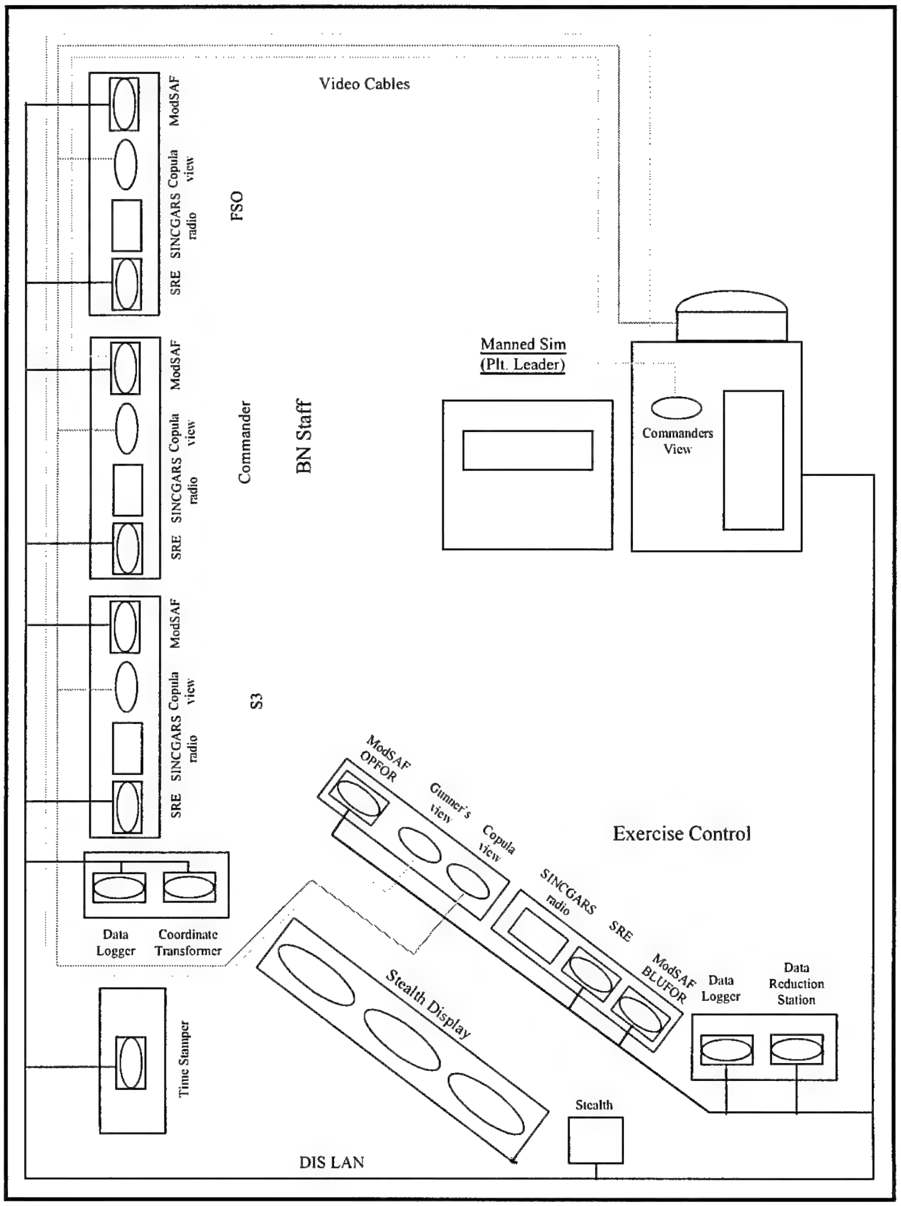

Figure 1 VTI Asset Layout at MWTB

The experiment was conducted using assets interconnected on Ethernet LANs with Ten Base T/AUI cables. Simulation assets used Distributed Interactive Simulation (DIS) 2.03 protocol. Table 1 lists assets used at the MWTB.

ADST II ASSET	PURPOSE	PROTOCOL
M1A2 Simulator	M1A1 Simulator	DIS
Stealth	Battlefield Display for Battle Master	DIS
ModSAF Workstations	Semi-Automated Forces for OPFOR, BLUFOR M1A2 wingman and artillery, three BLUFOR workstations for the Company Staff	DIS
Coordinate Converter	Correct discrepancies between ModSAF and M1A2 simulator	DIS
SRE	Simulated Radio Communications	DIS
Video Display Devices	Three for copula center view display, one for commander's ModSAF display, one for gunner's view display	RGB video cable
Video Signal Splitters and Scan Converters	Two splitters for the copula center view display, two splitters for the gunner's view display, one splitter and one scan converter for the commander's ModSAF view display	RGB video cable
Data Loggers	Record of DIS PDUs for Data Collection & Analysis	DIS
DIS Time Stamper	Time Stamp of DIS PDUs for Data Collection & Analysis	DIS

Table 1 ADST II MWTB Assets

The inventory of the equipment used for this experiment is listed below in Table 2. All equipment used in the VTI experiment was furnished by MWTB.

Description	Type or Model	System
	Company Staff	
Commander's Workstation		
Computer	SGI - Indy	ModSAF Blue #1
Keyboard	SGI	ModSAF Blue #1
Monitor	SGI	ModSAF Blue #1
Computer	SGI - Indy	SRE
Keyboard	SGI	SRE
Monitor	SGI	SRE
Radio	Card Cage	SRE
LAN Cables (Qty.=2)	LAN	ModSAF and SRE
Monitor	13" color monitor	Copula center view display
Scan Converter	Kaiser Electronics VIEW. RGB to Composite Scan Converter	Tank commander's ModSAF display
Video signal splitter	Extron RGB 112 PLUS Analog	Tank commander's

Description	Type or Model	System
	Distribution Amplifier	ModSAF display
S3's Workstation		
Computer	SGI - Indy	ModSAF Blue #2
Keyboard	SGI	ModSAF Blue #2
Monitor	SGI	ModSAF Blue #2
Computer	SGI - Indy	SRE
Keyboard	SGI	SRE
Monitor	SGI	SRE
Radio	Card Cage	SRE
LAN Cables (Qty.=2)	LAN	ModSAF and SRE
Monitor	13" color monitor	Copula center view display
Video signal splitter	Extron ADA3 Analog Distribution Amplifier	Copula center view display
Video cable (Qty.=4)	RGB video cable. Approximately 20 feet. Amplifier box to monitors.	Copula center view display
FSO's Workstation		
Computer	Sun Sparc station 20	ModSAF Blue #3
Keyboard	Sun	ModSAF Blue #3
Monitor	Sun	ModSAF Blue #3
Computer	SGI - Indy	SRE
Keyboard	SGI	SRE
Monitor	SGI	SRE
Radio	Card Cage	SRE
LAN Cables (Qty.=2)	LAN	ModSAF and SRE
Monitor	13" color monitor	Copula center view display
	Exercise Controller	
OPFOR Workstation		
Computer	SGI - Indigo 2	ModSAF OPFOR
Keyboard	SGI	ModSAF OPFOR
Monitor	SGI	ModSAF OPFOR
Monitor	13" color monitor	Copula center view display
Monitor	13" color monitor	Gunner's view display
Video signal splitter	TRUEVISION, Inc. VIDI/O BOX Analog Distribution Amplifier	Gunner's view display
BLUFOR Workstation		
Computer	Sun Sparc station 20	ModSAF Blue #4
Keyboard	Sun	ModSAF Blue #4
Monitor	Sun	ModSAF Blue #4
Computer	SGI - Indy	SRE
Keyboard	SGI	SRE
Monitor	SGI	SRE

Description	Type or Model	System
Radio and speaker	Card Cage	SRE
LAN Cables (Qty.=2)	LAN	ModSAF and SRE
Miscellaneous		
Computer	Sun Ultra 1	Data Logger/Data Reduction
Keyboard	Sun	Data Logger/Data Reduction
Monitor	Sun	Data Logger/Data Reduction
Line Printer	Genicom 4840e	Data Reduction
Computer	Sun Sparc station IPX	Backup Data Logger
Keyboard	Sun	Backup Data Logger
Monitor	Sun	Backup Data Logger
Computer	Micros 286/10 PC	Time Stamper
Keyboard	Micros	Time Stamper
Monitor	13" monochrome monitor	Time Stamper
Computer	Sun Sparc station 20	Coordinate Converter
Keyboard	Sun	Coordinate Converter
Monitor	Sun	Coordinate Converter
	Simulator	
M1A2 Manned Simulator		
Monitor	27" Flat panel display	Tank commander's ModSAF display
Computer	SGI – Indy	SRE
Keyboard	SGI	SRE
Monitor	SGI	SRE
LAN Cables	LAN	SRE
Video signal splitter (Qty.=2)	Extron ADA2 Analog Distribution Amplifier	Copula center view display and Gunner's view display
Video cable (Qty.=3)	RGB video cable. Approximately 50 feet.	Copula center view display, gunner's view display, tank commander's ModSAF display

Table 2 VTI Inventory

3.2 Description of System Components

This section discusses the description, functionality and operation of the system components, which includes the GFE models and their integration with the hardware at the MWTB.

3.2.1 World Modeler

The original Government SOW required the use of the Janus constructive simulation for the OPFOR and the company staff. The World Modeler consists of the Janus simulation and the J-Link DIS interface between Janus and the simulation network. The schematic display in the manned simulator was to be split off of the company commander's Janus workstation. The decision to remove the World Modeler from the experiment and use ModSAF workstations for this functionality instead was recommended and approved by all the customers during initial system integration and terrain correlation. The use of World Modeler could not provide the necessary realism for the manned simulator.

3.2.2 Manned Simulator

A single M1A2 simulator was used for VTI. A display of the company commander's ModSAF workstation was mounted to the left of the Tank Commander in the manned simulator. The company commander controlled this display.

3.2.2.1 Manned Simulator Enhancements

The manned simulator software was modified so that the simulator was invulnerable to direct fire from T80 and BMP2s. The /sim_cfg/models/damm.dat file was modified to implement this change.

3.2.3 ModSAF Operations

Modular Semi-Automated Forces (ModSAF) is a software model for creating and controlling entities on a simulated battlefield. The ModSAF for VTI consists of the standard ModSAF software, Version 3.0, with modifications to implement the VTI requirements. ModSAF was used for the Blue Force (BLUFOR) round out, the Red Force (OPFOR), and the company staff. BLUFOR ModSAF provided the M1A2 wingman and the M109 battery. OPFOR units were sequentially displayed BMP2 units. The company staff ModSAF workstations did not have any units assigned to them. All ModSAF workstations were run as "pocket systems", that is the front-end SAF Station and the rear-end SAF simulation were run on the same computer. Two Silicon Graphics, Inc. (SGI) Indy workstations, one SGI Indigo 2 workstation, and two Sun Sparc 20 workstations were used for the ModSAF workstations. Each workstation had at least 64 MB of RAM (more is better), 1 GB of hard disk space, at least 128 MB of swap space, and an Ethernet 10-BASE T port for connecting to the DIS network. The SGI workstations were using the IRIX 5.3 operating system. The Sun workstations were using the Solaris 2.5.1 operating system.

The initial software installation, power up operations, and operation of the user software was performed in accordance with the ModSAF User Manual. ModSAF operators were required for both the BLUFOR and the OPFOR during the experiment per the VTI SOW. Test subjects operated the company staff ModSAF workstations.

The VTI interface diagram for the ModSAF interfaces is shown in Figure 2.

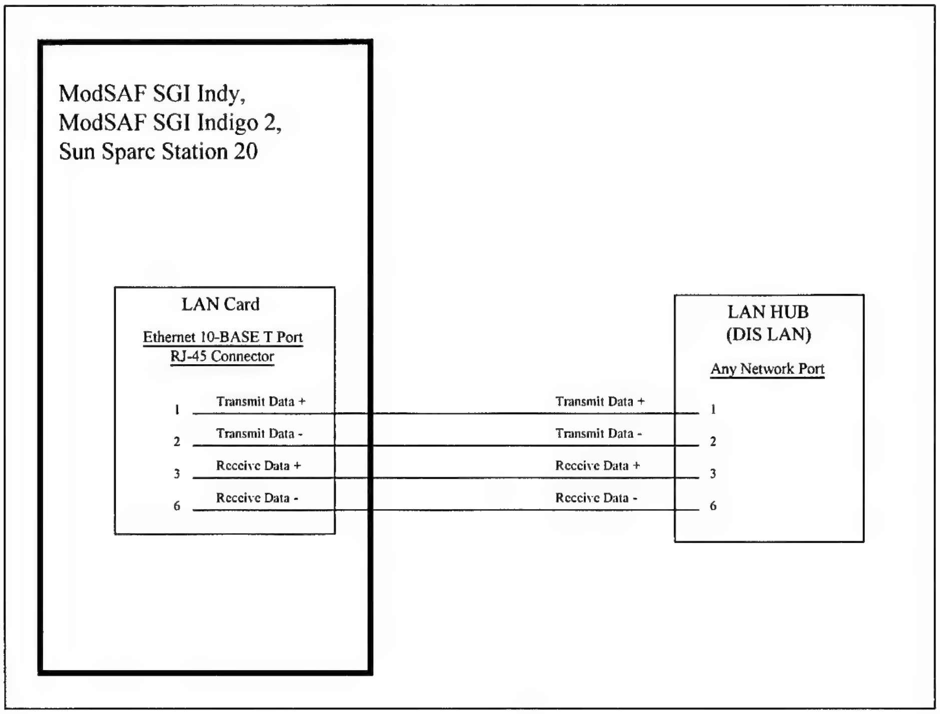

Figure 2 ModSAF Interface Diagram

3.2.3.1 ModSAF Enhancements

ModSAF version 3.0 was enhanced/modified for VTI to meet specific requirements. This enhanced version is known as VTI ModSAF 1.0. These changes include the addition of a target acquisition tool, the capability to remove emphasized contour lines, and increasing the vulnerability of BMP2s to indirect fire. The target acquisition tool allows operators at workstations displaying both friendly and enemy forces to select an enemy unit to be displayed on workstations displaying only friendly forces. Its intended use is to allow enemy units detected by the crew of a manned simulator to be displayed on friendly workstations as if they had been detected by a ModSAF entity. The operator selects a detector and one or more enemy targets from the entities displayed on his Plan View Display (PVD). A Contour Emphasis item was added to the PVD Controls tool menu. This allowed the operator to turn off emphasized contour lines by selecting every zeroth line for emphasis. The VTI ModSAF version 1.0 VDD (CDRL AB03) discuss these changes in detail.

3.2.4 Coordinate Converter

The coordinate converter bridges two DIS exercises running on the same network. The algorithm to calculate geodesic coordinates was improved for ModSAF version 3.0. These improvements have not been made to the M1A2 simulator. Consequently ModSAF disagrees with the M1A2 simulator on the coordinates of a known terrain feature. The coordinate converter can correct this discrepancy if the error is constant by adding the difference between the X, Y, and Z coordinates of the two systems. It reads PDUs from one exercise, adds the XYZ off set to the event/entity location, and then writes the PDU addressed to the

other exercise. ModSAF and the M1A2 simulator were members of different DIS exercises. Only ModSAF PDUs were logged so all exercise data uses the ModSAF coordinates. The coordinate transformer software was run on a SGI Indy workstation with at least 64 MB of RAM, 1 GB of hard disk space, at least 128 MB of swap space, and an Ethernet 10-BASE T port for connecting to the DIS network. The SGI workstation used the IRIX 5.3 operating system. The coordinate converter may not be necessary after the M1A2 is upgraded in the spring of 1998.

3.2.5 Data Logger

The Data Logger is an ADST II asset that captures the network traffic and places the data packets on a disk or tape file. The Data Logger performs the following functions:

a. Packet Recording - Receives packets from the DIS network, time stamps and then writes to a disk or tape.

b. Packet Playback - Packets from a recorded exercise can be transmitted in real time or faster than real time. The Data Logger can also suspend playback (freeze time) and skip backward or forward to a designated point in time. The logger can be controlled directly from the keyboard or remotely from the Plan View Display (PVD). Playback is visible to any device on the network (PVD, Stealth Vehicle, a vehicle simulator, etc.).

c. Copying or Converting - Files are copied to another file, which can be on the same or a different medium; and files from the older version of the Data Logger can be converted to a format compatible with the current version of the Data Logger.

For VTI, two data loggers were employed to capture the exercise. The two data loggers were placed on the DIS net to capture all DIS PDUs for analysis. One logger was a Sun Ultra 1 running under the Solaris 2.5.1 operating system with 128 MB of RAM, two 4 GB Hard Drives, and one 9 GB Hard Drive. The other logger was a Sun IPX running the Sun OS 4.1.3 operating system with 48 MB of RAM and a 1 GB Hard drive. The Sun IPX data logger was designated as a back up.

3.2.6 Time Stamper

The MWTB provided a Time Stamper that consisted of a time code generator. This time code generator produced time data in days, and since 1 January, in hour/min/sec format. It ran on an IBM-compatible Personal Computer (PC). The PC was programmed generate a Time PDU which was then issued on the DIS network each second. This provided the real world clock time on the logged data to assist in subsequent analyses.

3.2.7 SRE

The Single Channel Ground and Airborne Radio System (SINCGARS) Radio Emulator (SRE) was used for communications between the tank commander, the company staff, and the exercise controller. Five SGI Indy workstations running with the IRIX 6.2 operating system were used to host the SINCGARS Radio Model (SRM). Each workstation had at

least 64 MB of RAM, 1 GB of hard disk space, at least 128 MB of swap space, and an Ethernet 10-BASE T port for connecting to the DIS network.

The VTI interface diagram for the SRE interfaces is shown in Figure 3.

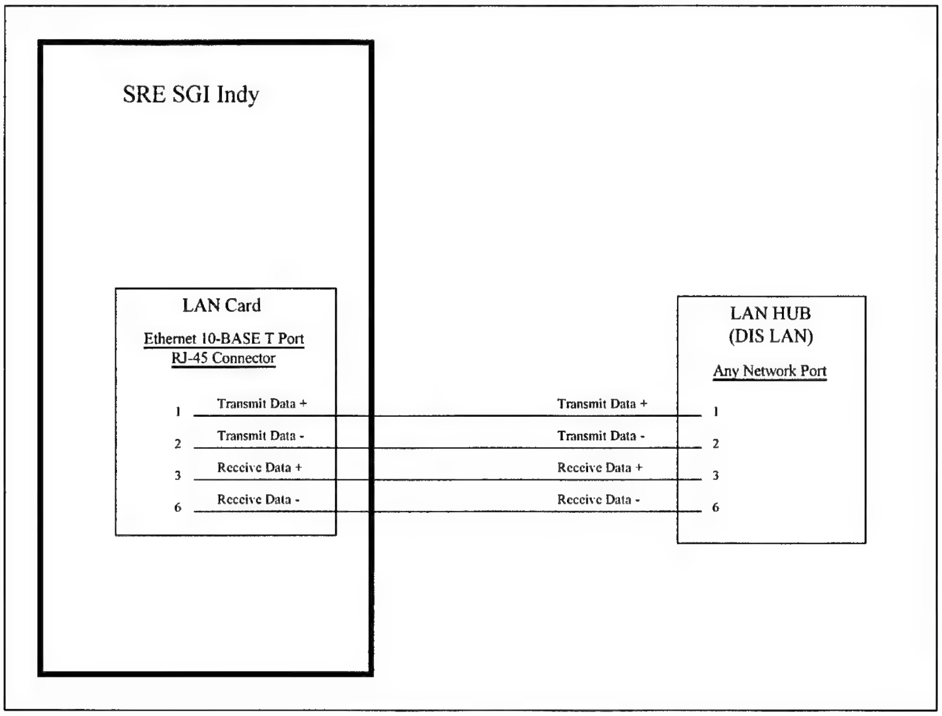

Figure 3 SRE Interface Diagram

3.2.8 Stealth System

The ADST II Stealth gives the Observer/Controller (O/C) personnel a "window" into the virtual battlefield allowing them to make covert observations of the action occurring during the scenario. In addition, through the use of the data logger, the Stealth gives observers and analysts an After Action Review (AAR) capability. The Stealth is a visual display platform that consists of a PVD, various input devices, and three video displays that provide the operator with a panoramic, 3D view of the battlefield.

The Stealth permits the controller to fly around the virtual battlefield and view the simulation without interfering with the action. The features of the Stealth allow the observer to survey the virtual battlefield from a variety of different perspectives, including:

a. Tethered View - Allows the user to attach unnoticed to any vehicle on the virtual battlefield.

b. Mimic View - Places the user in any vehicle on the virtual battlefield and provides the same view as the vehicle commander.

c. Orbit View - Allows the operator to remain attached to any vehicle on the virtual battlefield and to rotate 360° about that vehicle, while still maintaining the vehicle as a center point of view.

d. Free Fly Mode - Permits independent 3-D movement anywhere in the virtual battlefield.

3.2.9 DIS LAN Network Configuration

A standard DIS LAN configuration was used with Ten Base T/AUI cable.

3.3 Database and Scenario Development

A Grafenfels terrain database was created to support the experiment. The ModSAF and Stealth databases were 54 Km by 84 Km and were used with sunshine weather conditions. The Janus and J-Link databases were 50 Km by 50 Km. Terrain correlation testing was conducted between 8 and 19 December 1997 and 12 and 23 January 1998.

A series of four test scenarios and two training scenarios were developed to support VTI. The scenarios included overlays to support the mission. The Mounted Maneuver Battle Lab and Lockheed Martin Service Group (LMSG) MWTB personnel developed the overlays.

4. Conduct of the Experiment

4.1 Pilot Test

The Pilot Tests were conducted at the MWTB on February 23, 1998 and March 23, 1998. The Pilot Tests were used to rehearse the procedures to be used during the trial runs.

The TRR was held on February 19, from which LMC obtained permission to proceed with the experiment.

4.2 Experiment and Trial Runs

The trial runs for the experiment began February 24 and ended April 3, 1998. The experimental unit was a M1A2 and the company staff. The M1A2 simulator had a three-man crew of RAs. ModSAF provided the M1A2 wingman and artillery. RAs played the roles of the Company Commander and FSO for the company staff. A Test Director was provided by MWTB to support the trials. Four scenarios with multiple maneuver and target options were used. A trial run consisted of running a scenario using two or three maneuver-target combinations. Ten trial runs were scheduled for each day at the beginning of each team's two week test period. More trial runs were scheduled as the test teams became more proficient. In practice as many runs were made each day as could be comfortably made. In approximately half of the trial runs a schematic view of the battlefield was provided to the tank commander and a virtual view was provided to the company staff. Two teams of test subjects were used for the experiment. The first team was used for the first three weeks of testing and then were replaced by the second test team for the forth and fifth weeks.

<u>Week One</u> was February 24-27. Forty trial runs were scheduled. Forty trials were run and validated by the Test Director. The start of the trial runs was delayed half an hour the first day to reset the radios locations. The radios at the company staff were out of range of the manned simulator after switching from the pilot test runs to trial runs. One run was aborted due to a procedural error. A software problem regulating speed in the manned simulator affected several runs and caused one trial to be aborted. Initially the throttle was stuck in the full open position and the simulator could be stopped only by taking it out of gear. On-site technicians reset the configuration parameters and rebooted the simulator. After making these changes, the simulator could only achieve speeds of about 10 kilometers per hour. Again, on-site technicians reset the configuration parameters and rebooted the simulator. Remaining runs were made with no other anomalies. The Test Director requested that the gunner's view be displayed at the exercise control station to aid in the verification of target detection. The gunner's view display was setup February 25. There were no major issues during this week.

<u>Week Two</u> was March 2-6. Fifty trial runs were scheduled. However, the experiment was suspended March 4-14 for a higher priority experiment. Fourteen trials were run March 2-3 and validated by the Test Director. Totals at the end of Week Two were 53 runs completed and validated. There were no major issues during this week.

Week Three was March 16-20. The morning of March 16 was used for system checkout. Forty-five trial runs were scheduled and fifty-two trial runs were completed and validated. This gave the first team a total of 109 trial runs. There were no major issues during the week.

Week Four was March 23-27. March 23 was reserved for training and pilot tests for the second team. Forty trial runs were scheduled. Fifty-nine trial runs were completed and validated by the Test Director. Cumulative totals for the experiment were 168 trial runs completed and validated by the Test Director. All subcomponents of the system were operational.

Week Five was March 30 to April 3. Fifty trial runs were scheduled. Eighty trial runs were completed and validated by the Test Director. A total of 248 trial runs were completed and validated by the Test Director for the experiment. The first test team had 109 trial runs and the second had 139 trial runs. All subcomponents of the system were operational.

Dr. Hunt conducted the analysis of the experiment data. MWTB provided a RA to act as the Test Director. The Test Director was present throughout the experiment and validated the trial runs on a daily basis. Data was collected on every run per the requirements in the Data Collection Plan established by Dr. Hunt. This data was screened daily by MWTB personnel and then turned over to Dr. Hunt for analysis.

5. Observations and Lessons Learned

Observation #1

Janus vehicle movement is jerky and unrealistic as seen from the M1A2 manned simulator and stealth workstation.

Discussion #1

Seen from the manned simulator Janus entities appear to drift off course and then suddenly jerk back on course. The timing of the corrective jerks correlates to the Janus movement update cycle of six seconds. Janus sends the unit position to J-Link each time it is updated. J-Link creates an Entity State PDU that it sends to the DIS network. J-Link also performs dead reckoning for Janus units between Janus updates. It appears that there is an error in the dead reckoning algorithm used by J-Link. Another problem is that Janus entities do not accelerate smoothly. All starts, turns, speed changes, and stops are instantaneous.

Lesson Learned #1

The error in the J-Link dead reckoning algorithm must be corrected before the World Modeler can be used with virtual simulators. The Janus movement update cycle should be shorted for exercises involving manned simulators.

Observation #2

The roll of Janus vehicles traveling on roads is inconsistent with the slope of the road as seen from the manned simulator.

Discussion #2

M1A2 and stealth roads are level from curb to curb. Janus roads have the slope of the underlying terrain. Thus a Janus tank seen from the simulator may move down a road with one track on the road and the other about a foot above or below the road surface. The pitch and roll of Janus vehicles are calculated by J-Link.

Lesson Learned #2

The movement of Janus entities can be made to appear more natural if J-Link were modified to set the roll of entities on roads to 0°. This will correct the roll discrepancy in most cases.

Observation #3

Janus ground vehicles fly and tunnel into the ground as seen from the M1A2 manned simulator.

Discussion #3

ModSAF and the M1A2 simulator use a three dimensional coordinate system with the origin at the center of the earth. Janus uses a flat earth coordinate system. J-Link has its own terrain database based on a three dimensional coordinate system. J-Link uses this map to translate between Janus and DIS coordinates. The display of the J-Link map shows no terrain details so it is impossible to determine whether it is consistent with either the Janus terrain database or the ModSAF and M1A2 databases. ModSAF terrain features were shifted about 125 meters northeast relative to the manned simulator. The shift between the ModSAF and the manned simulator was attributed to improvements made to ModSAF's coordinate calculations that were not incorporated into the simulator. This discrepancy was corrected by adding a constant offset to the M1A2 simulator's position on the ModSAF map and subtracting the offset from ModSAF entities on the M1A2 map. Janus terrain features matched the manned simulator database in the X and Y directions but not in the Z direction. The difference in the Z direction was inconsistent, therefore no offset could be found that would correct the discrepancy as was done for the M1A2 and ModSAF.

Lesson Learned #3

It is not clear where the origin of discrepancy is between Janus and the M1A2 and ModSAF. The two most likely places are errors in the map J-Link uses or in the algorithm J-Link uses to convert between the Janus flat earth and DIS geodesic coordinate systems. The source of possible errors and the magnitude of the errors would be reduced considerably if all of the DIS components used the same base map and coordinate calculations. This means modifying J-Link to use either the ModSAF or the M1A2 terrain database and upgrading the coordinate calculation algorithms used by J-Link and the M1A2 simulator.

6. Conclusion

The Virtual Terrain Imagery (VTI) experiment was a technically challenging effort that achieved its goal. The VTI environment that was created has allowed the MWTB to collect, analyze and evaluate the resulting data which should aid in developing better future simulation exercise enhancements.

7. Points of Contact

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Acronym List

AAR	After Action Review
ADST	Advanced Distributed Simulation Technology
BLEP	Battle Lab Experiment Plan
BLUFOR	Blue Forces
CDRL	Contract Data Requirements List
CGI	Computer Generated Image
CIG	Computer Image Generator
DDL	Digital Data Link
DO	Delivery Order
DIS	Distributed Interactive Simulation
FTP	File Transfer Protocol
GB	Gigabytes
GFE	Government Furnished Equipment
GUI	Graphical User Interface
H/W	Hardware
I/O	Input/Output
IPR	In Progress Review
LAN	Local Area Network
LMC	Lockheed Martin Corporation
LMSG	Lockheed Martin Service Group
M1Ax	Abrams Main Battle Tank ("x" = variant)
MB	Megabytes
ModSAF	Modular Semi-Automated Forces
MMBL	Mounted Maneuver Battle Lab
MWTB	Mounted Warfare Test Bed
OPFOR	Opposing Forces
ORSA	Operational Research System Analyst
OS	Operating System
OTW	Out-The-Window
PC	Personnel Computer
PDU	Protocol Data Unit
PM	Program Manager
POC	Point of Contact
PVD	Plan View Display
RAM	Random Access Memory
RP	Role Player
SAF	Semi-Automated Forces
SGI	Silicon Graphics Industries
SIMNET	Simulation Network
SINCGARS	Single Channel Ground and Airborne Radio System

SOW	Statement of Work
SRE	SINCGARS Radio Emulator
SRM	SINCGARS Radio Model
STRICOM	(US Army) Simulation Training and Instrumentation Command
TOR	Technical Office Representative
TRR	Test Readiness Review
UTM	Universal Transverse Mercator
VDD	Version Description Document
VTI	Virtual Terrain Imagery

Appendix A Reduced VTI Experiment Data

The reduced automated and manually collected data from the experiment is being maintained within the ADST II Configuration Management (CM) library under CM control numbers:

MD0710	VTI Test Data
MD0717	VTI Experiment Scenario Data Final Baseline
MD0720	VTI Support Data 1.0